IMAGE PICKUP DEVICE AND ITS COVER PLATE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a transparent cover plate that shields a solid state imaging device of an image pickup device mounted in, for example, a digital still camera or digital video camera.

2. Description of the Related Art

Conventionally, in the art of digital still or video cameras, an optical low-pass filter or an infrared cut-off filter is interposed between a taking lens and an image pickup device to improve the quality of images taken by the cameras. The optical low-pass filter is used to suppress moiré fringes caused by beats or interference between a periodic pattern of an object and a pitch of pixels, in the image pickup device. The infrared cut-off filter prevents adverse effects of infrared rays to a captured image. However, the conventional structure for mounting the optical low-pass filter or infrared cut-off filter requires a comparatively large space between the taking lens and the image pickup device. Accordingly, conventional structures limit design flexibility along the optical axis between the taking lens and the image pickup device.

The foregoing problem may be settled by disposing the

optical low-pass filter or infrared cut-off filter as close to the image pickup device as possible. However, when the optical low-pass filter or infrared cut-off filter is disposed closer to the image pickup device, an unfavorable effect to the quality of the taking images, caused by dust on the filters, increases. Further, the conventional optical low-pass filter, infrared cut-off filter and cover glass are insulators, thus they attract dust in the air by electrostatic attraction. Particularly, when lithium niobate ($LiNbO_3$) is utilized as an optical low-pass filter, as disclosed in Japanese Unexamined Patent Publication No. 11-282047, the filter attracts a considerable amount of dust since lithium niobate has strong pyroelectricity characteristics.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide a transparent cover plate for a solid state imaging device which is able to prevent dust collecting on the surface of the cover plate. Further, an object of the present invention is to provide an image pickup device that utilizes the above transparent cover plate.

According to the present invention, a cover plate comprising a transparent cover plate member and conductive film layer is provided to cover an opening of a casing in which a solid state imaging device is disposed. The

transparent cover plate member hermetically covers the opening and the outermost surface of the transparent cover plate member is covered with a conductive film layer.

Further, according to the present invention, an image pickup device is provided that comprises a solid state imaging device, a casing, a transparent cover plate member and a conductive film layer. The solid state imaging device is disposed in the casing, and the transparent cover plate member hermetically covers an opening of the casing. The conductive film layer covers the outermost surface of the transparent cover plate member.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects and advantages of the present invention will be better understood from the following description, with reference to the accompanying drawings in which:

Fig. 1 is a front view showing an image pickup device to which a first embodiment of the present invention is applied;

Fig. 2 is a sectional view on line II-II in Fig 1, showing the image pickup device of the embodiment;

Fig. 3 illustrates a sectional view of an image pickup device to which a second embodiment of the present invention is applied;

Fig. 4 illustrates a sectional view of an image pickup device to which a third embodiment of the present invention

is applied;

Fig. 5 illustrates a sectional view of an image pickup device to which a fourth embodiment of the present invention is applied;

Fig. 6 illustrates a sectional view of an image pickup device to which a fifth embodiment of the present invention is applied;

Fig. 7 is a table that shows deposit conditions and properties of a film in examples 1 and 2;

Fig. 8 is a graph that shows a spectral property of transmittance of a conductive film in example 1; and

Fig. 9 is a graph that shows a spectral property of transmittance of a conductive film in example 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is described below with reference to embodiments shown in the drawings.

Fig. 1 and Fig. 2 show a plane view and sectional view of the image pickup device with a transparent cover plate member to which an embodiment of the present invention is applied. Note that Fig. 2 is a cross section along the line II-II of Fig. 1.

A casing 11 is made in a shape of a flat ceramic box and a rectangular recessed portion 12 is formed inside the casing 11. A solid state imaging device 13 is placed on the base of the recessed portion 12. In Fig. 1, the solid state

imaging device 13 is indicated as a hatched portion depicted within a phantom line. On the inner periphery of the recessed portion 12, a step 14 is formed. Instead of a conventional cover glass, a transparent cover plate member 17a is fitted into the step 14 to cover and shield the solid state imaging device 13. The transparent cover plate member 17a is a laminate rectangular plate comprised of an optical low-pass filter 15 and infrared cut-off filter 16. The transparent cover plate member 17a is mounted to the casing 11 so that the infrared cut-off filter 16 is arranged inside the casing 11. The optical low-pass filter 15 is comprised of two lithium niobate (LN) plates 15a and 15b, by way of example, which are adhered together and integrated. On the outer surface of the lithium niobate plate 15a, which is arranged on the side opposite to the surface to which the infrared cut-off filter 15 is adhered, a conductive film (layer) 18 is coated. For example, the conductive film 18 is a thin metallic film layer of Cr or Au, etc. Namely, the conductive film 18 is formed on the outer surface of the outermost member from the solid state imaging device 13 of the transparent cover plate member 17a. The edges of the transparent cover plate member 17a are adhered to the step 14 by a bonding agent. The recessed portion 12 is filled with an inert gas, i.e. nitrogen gas, and is enclosed by the transparent cover plate member 17a. Namely, the transparent cover plate member 17a

hermetically seals the casing 11 and shields the solid state imaging device 13 from the open air. Note that, deposition of the thin coating of conductive material on the optical low-pass filter 15 is carried out by a vacuum metal deposition process or cathode sputtering process, for example. In this embodiment, the optical low-pass filter 15 is comprised of two lithium niobate plates, however, it may comprise a plurality of crystal or lithium niobate plates.

According to the first embodiment of the present invention, as an alternative to a conventional cover glass, the transparent cover plate member, which is comprised of a laminated optical low-pass filter and infrared cut-off filter, is used to cover the solid state imaging device. Therefore, there is no need to provide a conventional mounting structure for an optical low-pass filter and infrared cut-off filter, and the available space is increased between the taking lens and the solid state imaging device. Consequently, this allows various design options along the optical axis between the taking lens and the image pickup device 13 and also simplifies the structure of the optical system utilized in the image pickup device. Further, since the outer surface of the transparent cover plate member is coated with the conductive film, an electrical charge in the laminated plate of the transparent cover plate member, i.e. the LN plate, is prevented, even though the pyroelectricity

characteristic of the plate is induced by temperature variance or other surrounding conditions. Therefore adsorption of dust is prevented and the image quality of the solid state imaging device improves. Furthermore, since the infrared cut-off filter is hermetically sheltered from the open air by the optical low-pass filter, the quality of the infrared cut-off filter 20, which has moisture absorbent properties, is protected from humidity induced deterioration.

A second embodiment of the present invention is explained with reference to Fig. 3.

In the second embodiment, the arrangement of the optical low-pass filter 15 and the infrared cut-off filter 16 in the first embodiment is changed. Namely, the transparent cover plate member 17b is mounted on the casing 11, so that the infrared cut-off filter 16 forms the outer side of the transparent cover plate member 17b and the optical low-pass filter 15 forms the inner side of the transparent cover plate member 17b. The conductive film 18 is formed on the outer surface of the infrared cut-off filter 16. Other structure of the second embodiment is the same as the first embodiment. Consequently, according to the second embodiment, a similar effect as in the first embodiment is obtained.

With reference to Fig. 4 to Fig. 6, third to fifth

embodiments of the present invention are explained. Note that, Fig. 4 to Fig. 6 respectively illustrate a cross section of the third to fifth embodiment.

Transparent cover plate members 17c, 17d and 17e utilized in the third, fourth and fifth embodiments are laminates of an optical low-pass filter, infrared cut-off filter and cover glass. Namely, in the third embodiment, the optical low-pass filter 15, which is comprised of LN plates, the infrared cut-off filter 16 and a cover glass 19 are laminated in this order, from the outer side and form a transparent cover plate member 17c that is attached to the casing 11. The outermost surface of the optical low-pass filter 15 is covered with a conductive film 18, comprised of Cr, Au, etc. In the fourth embodiment, a transparent cover plate member 17d is a laminate of the cover glass 19, optical low-pass filter 15 and infrared cut-off filter 16 in that order, from the outer side, and the conductive film 18 is deposited on the outside surface of the cover glass 19.

In the fifth embodiment, in addition to the third and fourth embodiments, one more cover glass 19 is applied to a transparent cover plate member 17e. Namely, the transparent cover plate member 17e in the fifth embodiment is comprised of the cover glass 19, optical low-pass filter 15, infrared cut-off filter 16 and cover glass 19, which

are laminated in that order, from the outer side, and on the outside surface of the cover glass 19 disposed at the outermost position, the conductive film 18 is deposited.

As described above, according to the third, fourth and fifth embodiment, a similar effect as the first and second embodiment is obtained.

Note that, the form and measurements of the optical low-pass filter and the distance between the low-pass filter and the solid state imaging device can be altered as required. In the above embodiments, examples of the conductive film were Cr and Au, however, it can be replaced by other metals, for example, Al, Cu, Ni, Mg or Pt. The conductive film can be also replaced by ITO (Indium-Tin-Oxide), which may be applied as a transparent electrode. For ITO, vacuum metal deposition, cathode sputtering, dip or spin coat process, etc., may be applied to form the conductive film on the surface of the transparent cover plate member. Further, the order of laminate members, such as infrared or optical low-pass filters and cover glasses, is not restricted to the above embodiments and may be altered as required.

Figs. 7-9 show examples of dust eliminating effects of the Cr and Au conductive films and their properties, such as film resistance, surface potential and spectral properties. Fig.7 is a table that shows deposit conditions

and film properties in examples 1 and 2. Fig. 8 and Fig. 9 respectively indicate spectral properties of transmissivity of the conductive films in examples 1 and 2. In each example 1 and 2, the conductive film is created on the LN plate by the vacuum metal deposition process.

[EXAMPLE 1]

Example 1 relates to a Cr conductive film. The deposit conditions for the Cr conductive film are shown in the table of Fig. 7. Namely, the deposition of the Cr conductive film was carried out under the following conditions: vacuum intensity at 2.0×10^{-5} torr, temperature of the LN plate at 100 °C and speed of the deposition at 20 nm/min. The thickness of the Cr conductive film was 1.7 nm. With above conditions, the film resistance between 1 cm distant electrodes was 870 kΩ. Surface potential of the LN plate before the Cr coating was about 0.5 kV and after the Cr coating was about 0.1 V. Hence the amount of surface potential of the LN plate was reduced by about three digits by the deposition of the Cr film. Note that, the surface potential was remotely measured by the DIGITAL STATIC METER MODEL 204 of Hugle Electronics Inc. To observe the effect of the Cr film coating, dust was sprinkled on a sample of the above Cr film coated LN plate, and a dust removal test was made with a blower. As a result, dust 10 μm in size, or above, was removed by the blower.

It was also considered that, when a cover plate of the solid state imaging device is coated with a metallic film, transmissivity of the cover plate may decline, so that sensitivity of the image pickup device may decrease. Fig. 8 is a graph of the transmissivity of the LN plate with the above Cr film, and the abscissa indicates wavelengths of light. As shown in the graph, a loss of transmissivity by the conductive film of example 1, in the visible rays, is about 15 percent. However, with the solid state imaging device, which detects image signals by electrical signals, this loss can be easily restored by gain control of an amplifier or by image processing software on a computer system. Note that, since the deposited film is stable, a Cr conductive film shows high durability, as well as high conductivity. Therefore, it can provide prevention effect of electrification and durability even though the film is thin. As a result it is possible to increase the transmissivity of the cover plate.

[Example 2]

Example 2 relates to an Au conductive film. In example 2, the conductive film is deposited under the following conditions: vacuum intensity at 2.0×10^{-5} torr, temperature of the LN plate at 100 °C and speed of the deposition at 3.3 nm/min. The thickness of the Au conductive film was 3.3 nm. With the above conditions, the

film resistance between 1 cm distant electrodes was above 40 MΩ. Surface potential of the LN plate before the Au coating was about 0.5 kV and after the Au coating was about 1.0 V. Namely, the surface potential of the LN plate was reduced about two digits by the deposition of the Au film coating. Further, in the same way as in example 1, to observe the effect of the Au film coating, dust was sprinkled on a sample of the Au film coated LN plate and a dust removal test was made with a blower. As a result, dust 10 μm in size or above was removed by the blower.

Fig. 9 is a graph of the transmissivity of the LN plate with the Au film, and the abscissa indicates wavelengths of light. As shown in the graph, the spectrum of transmittance by the Au conductive film is slightly inferior to the Cr conductive film of the example 1. However, as in example 1, a loss of transmissivity in visible rays averages about 15 percent.

Although the embodiments of the present invention have been described herein with reference to the accompanying drawings, obviously many modifications and changes may be made by those skilled in this art without departing from the scope of the invention.

The present disclosure relates to subject matter contained in Japanese Patent Application No. 2000-157900 (filed on May 29, 2000), which is expressly incorporated

herein, by reference, in their entireties.